Quality and Product Differentiation as Price Determinants in the Marketing of Fresh Pacific Tuna and Marlin

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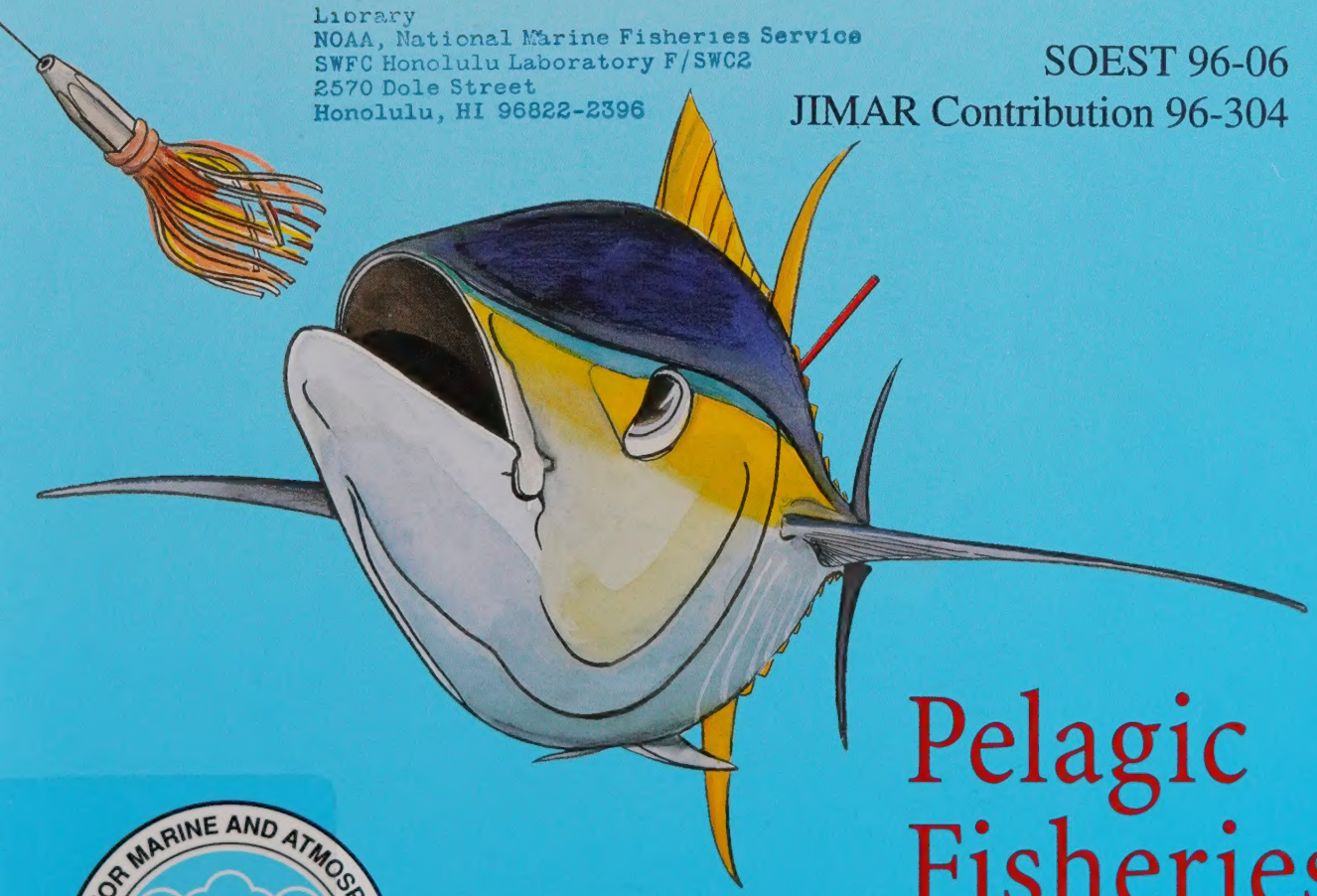

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This research is funded by Cooperative Agreement No. NA37RJ0199 from the National Oceanic and Atmospheric Administration. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its sub-agencies.

ABSTRACT

This study examines the highly differentiated market for fresh tuna products and the relationship between quality characteristics and market value. Fresh tuna are individually graded and each fish is directed to the most appropriate (and profitable) market and end use. The range of acceptable quality within each market niche and consumer application defines the grade and, ultimately the price, of fresh tuna. By contrast, marketing options are greatly reduced for conventionally frozen tuna, most of which is sold for canning without individual grading of fish.

The influence of quality gradations on fresh tuna pricing in the Hawaii market is assessed quantitatively by analyzing over 8,000 individual tuna transactions during the summers of 1994 and 1995. Hawaii grading standards are compared and "calibrated" with those in major U.S. and Japanese fresh tuna markets. Market connectedness is demonstrated by comparing tuna prices in Hawaii with prices of equivalently-graded fish in export markets.

Fresh marlin, which is the largest by-catch of tuna fisheries and enters the same markets as fresh tuna, is a secondary focus of the research.

Tuna quality grading is a highly subjective process. Graders can easily observe fish body appearance but they can directly sample only a small section of the fish muscle. There are usually only a few seconds to evaluate and assign a grade for each tuna during purchasing or export processing. Grading criteria are not always applied uniformly but a common understanding of quality standards evolves over time between fresh tuna sellers and buyers in each market.

Research results will enable Pacific island resource managers to value pelagic fisheries under varied marketing scenarios. The findings also suggest some strategies that could enhance the economic viability of island-based tuna fisheries.

1.0 SUMMARY OF FINDINGS

- Fresh tuna is highly differentiated in product types and market niches.
- Fresh marlin is less differentiated than fresh tuna.
- Wide variation in fresh tuna prices corresponds with varying quality requirements of highly differentiated end uses.
- Through quality grading, tuna acquire individual identities (i.e., quality grades) that can be correlated with market prices. Premium products command higher prices than lower quality products.
- Tuna grades integrate effects of harvesting, handling and storage on fish quality.
- Quality grades define market and price interactions among tuna from multiple sources and fishing gear types.
- The future market trend is toward even greater differentiation in product types and associated quality requirements.

2.0 POSSIBLE APPLICATIONS OF FINDINGS

- Without consideration of tuna quality grades, market conditions and price trends may be misinterpreted. Fishery managers should be aware that the unit value of fresh tuna varies substantially under different marketing scenarios.
- Tuna market competition in Hawaii and elsewhere is not based narrowly on gear type, but more broadly on quality, or tuna grades.
- Fresh tuna harvesters in the Pacific islands are well aware of market conditions and price fluctuations, but important quality information is not always communicated back to them.
- The proportion of premium grade tuna products in landings by Pacific island tuna fishermen could be increased through better quality control.
- Greater diversity in products could add value to Pacific island tuna fisheries.
- Some apparent opportunities for fresh tuna and marlin export are not being fully exploited.
- Tuna that is landed fresh should be clearly distinguished from frozen tuna landings in commercial fishery statistics.

3.0 PROBLEM STATEMENT AND RESEARCH OBJECTIVES

Frozen tuna is traded as a commodity and is destined primarily for a single end product—canned tuna. The market value of the raw material is determined principally by tuna species and size. It is uncommon for raw tuna prices to fluctuate by more than $0.15/lb[1].

In dramatic contrast, the price of *fresh tuna* can range from less than $0.50/lb to well over $5.00/lb (whole weight basis), even within identical size classes of a single species from a single fishing trip. Price variations in the fresh tuna market are subject to many interpretations, including some that claim bias against particular source areas or gear types.

The primary research objective of the present study is *to determine if wide price variations are related to the highly differentiated market for fresh tuna products*. Specific objectives are these:

- Define product types and uses of fresh tuna.
- Demonstrate that tuna grading is the industry-wide mechanism that differentiates products and associated quality requirements and links them to market niches.
- Calibrate tuna grading standards used in major markets.
- Quantitatively examine relationships between fresh tuna grades and prices in the Hawaii market.
- Test whether geographically separate markets for fresh tuna are inter-connected through quality and price differentiation.
- Forecast international outlook for fresh tuna industry and assess the implications for Pacific island fisheries.
- Discuss possible application of the research to fishery management.

Fresh marlin, the largest by-catch of tuna hook-and-line fisheries, enters the same markets as fresh tuna and is a secondary focus of the research.

4.0 PRODUCT TYPES, END USES, AND MAJOR MARKETS

The hypothesis evaluated is that *multiple specialized end products and uses* (i.e., market niches) cause wide variations in quality requirements and fresh tuna prices. The fresh tuna industry, originally focused on *sashimi* markets, is becoming more complex because of diversification in food preferences, products and marketing niches. The fish characteristics most important to fresh tuna buyers are those associated with consumer satisfaction. This varies greatly with how the fish are prepared and consumed.

[1] Throughout this report, lb is the abbreviation of pound (2.2 kg).

4.1 Fresh Tuna Products

There are four general end uses for fresh tuna. These are ranked in the usual order of raw material value:

- raw
- cooked
- specialty foods
- canned

No marlin is canned, but otherwise the end uses are generally the same as for tuna.

4.1.1 *Sashimi* tuna

Sashimi is the Japanese term for "raw fish" but it means much more than simply eating fish that has not been cooked. The experience of eating *sashimi* and *sushi* (small pieces of raw and cooked seafood on top of seasoned rice), like most Japanese cuisine, is enjoyed visually as well as tastefully. *Sashimi* and the use of *sashimi* in the preparation of *sushi* require the freshest fish because off flavors are more readily apparent in raw fish than in seafood that is cooked and heavily seasoned.

Within the tuna grades which can be considered for *sashimi*, there is an extremely wide range of quality and price, from the "consumer" or "medium" grade to the obscenely expensive and premium grade for which the Japanese *sushi* bar is famous. Discerning consumers prize tuna muscle that is bright red and translucent. *Sashimi* tuna with high oil content (*toro*) has a rich, "melting" taste.

4.1.2 Cooked tuna

Fresh tuna is nearly as popular as swordfish and salmon in the U.S. grilled seafood market. A wide range of tuna grades is grilled, from a high quality that could be eaten raw (and is cooked rare) to a quality level not much superior to canning grade. The difference is apparent by examining the menu. "White tablecloth" restaurants often serve "seared," "blackened," or "cajun-style" tuna steaks, whereas diners and lunch counters serve fried tuna steaks and burgers. Chefs who prepare rare tuna steaks often require initial product comparable to that used for *sashimi*.

4.1.3 Specialty foods

Small amounts of raw tuna are processed for dried, smoked, and other value-added products. Several "meat-like" products, including tuna hams, sausages, and burgers, have recently appeared in the market. These end uses of lower quality fish are an alternative to canning.

4.1.4 Canned tuna

The canned tuna market relies heavily on fish frozen at sea, primarily from purse seine fleets and secondarily from pole-and-line fleets. Some longline fishing fleets target albacore tuna for the premium canning market but longliners fishing for the *sashimi* market try to minimize the amount of "reject" fish that is sent to canneries. Canneries may help salvage a portion of operating cost but the low prices for canning grade fish (except for albacore) cannot usually sustain fresh tuna fisheries.

4.2 Major Markets

Major markets for fresh tuna exist in Hawaii, the continental U.S. and Japan. Substantial markets are developing in Korea and Europe. Of the South American tuna-producing nations, only Venezuela has a significant domestic demand for tuna products other than canned.

4.2.1 Hawaii

Hawaii is a primary producer, exporter, importer, and significant consumer of fresh tuna. The average daily consumption of tuna, including skipjack, is on the order of 10 metric tons[2], or about 3,500 metric tons on an annual basis. Hawaii enjoys direct access to fresh tuna from domestic longline, handline, and trolling fleets. Fresh tuna imports arrive regularly from throughout the Pacific basin.

Virtually all domestic and imported tuna is consumed fresh by a knowledgeable and discriminating consumer population. According to marketers and consumer surveys, at least 40% is consumed raw as sashimi or *poke* (raw fish cubes with relishes). Raw tuna seared on the outside is served in restaurants as "blackened sashimi, seared ahi" and other creative names.

The *sashimi* market places a premium on large, high quality fish but Hawaii's diversified tuna market is able to absorb the full range of tuna species, sizes, and quality levels. Yellowfin and bigeye tuna (*ahi*), as well as skipjack tuna (*aku*), are the preferred species. When the former are in short supply and high priced, albacore is sometimes substituted. The latter is often marketed as *ahi tombo* in an attempt to associate this fish with the more popular yellowfin and bigeye. Small quantities of albacore are prepared as *sashimi* or other raw dishes but the principal use is grilling.

Fresh blue marlin (*kajiki*) and striped marlin (*nairagi*) are among the most affordable seafoods in Hawaii. They are especially popular with low-income and fixed-income consumer groups. Marlin with high fat content receives price premiums in the *sashimi* market.

4.2.2 Continental U.S.

Consumption of fresh and frozen tuna in the U.S. exceeds 40,000 metric tons per year. About half of this amount is believed to be consumed fresh. Marketing options are more limited than in

[2] The metric ton (10^3 kg ~2205 lb) is used throughout this report.

Hawaii and the predominant demand is for cooking-grade tuna. Fresh tuna is promoted as a healthier food than meat, yet similar to beef in appearance and ease of handling and cooking. Continued growth is expected in the U.S. market for grilling-grade tuna (Joseph, 1996; Munoz, 1996). The demand is mostly for dressed (headed and gutted or h&g) tuna weighing more than 40 lb (18 kg). Smaller fish cannot be portioned into dinner plate-sized servings. Yellowfin is the tuna species preferred for grilling but fresh albacore, which is generally priced lower, accounts for a growing share of the retail tuna market.

There are significant regional differences in the U.S. fresh tuna market. West coast buyers have higher purchasing standards and are willing to pay higher prices for medium grade tuna than other geographic regions. A smaller and more specialized *sashimi* market that requires higher grade tuna is also centered on the West Coast.

Fresh marlin is not only less popular than fresh tuna but, in some areas of the U.S., there is active lobbying by gamefishing groups to keep marlin off the menu. Marlin species have gamefish status in California and cannot be sold. Atlantic marlin is banned from U.S. markets on the East Coast but Pacific marlin, with proper certification, is legal for sale there. South America is the major producer of fresh marlin entering the U.S. market.

4.2.3 Japan

Japan is the world's largest consumer and importer of tuna. Japanese consumers spend more on tuna than any other fresh seafood. *Sashimi* tuna is harvested all over the world but most is exported to the Japanese market.

The *sashimi* market ranks bluefin, bigeye, yellowfin, and skipjack tuna in general order of desirability but regional species preferences exist. For instance, Tokyo and Sendai are known to be good markets for high-fat bluefin and bigeye tuna, whereas the leaner yellowfin is preferred in Osaka and Nagoya. The pink muscle of marlin is preferred to the red muscle of tuna in other areas of Japan, especially around Fukuoka and Sapporo.

Fresh tuna accounts for about 25% of *sashimi* tuna consumption in Japan. The remainder is thawed tuna processed from fish frozen and stored at ultra-low temperatures ($< 60^{\circ}C$). Annual consumption of fresh and frozen sashimi tuna was relatively stable from 1989 to 1991 (490,000 metric tons) but increased to higher levels (520,000 metric tons) in 1992-1993 (Anon., 1994).

Much of the increase is attributable to growth in the value-added market sector. Greater availability of affordably priced, medium grade *sashimi* tuna has altered the image of fresh tuna from a luxury food for celebration to an item that can be eaten anytime. Socioeconomic changes in Japan in the 1990s (increased income, more women in the workplace) have caused an emphasis on greater convenience in food preparation and handling (Williams, 1996), a trend known as the "fresh food rush."

The *sashimi* market has become more differentiated, with both seafood discount stores and gourmet food stores offering options in product quality, price, form and convenience (Williams, 1996). Much more *sashimi* is being eaten in the home. Retail packs are increasing in popularity.

This market is enormous and is estimated to produce over one billion dollars in retail sales (Taya, 1996).

Even with these trends in consumer behavior, there appears to be little potential for continued increases in Japanese *sashimi* consumption and the market is thought to have reached its upper limit (Taya, 1996; Tanabe, 1996). One contributing factor may be a dietary shift, especially among young Japanese, toward greater meat consumption.

Domestic production of tuna in Japan is declining and there is increasing reliance on imports. According to some sources, domestic longline, pole-and-line, and purse seine fleets are all operating at a deficit (Tanabe, 1996). Domestic production of frozen *sashimi* tuna fell to 200,000 metric tons in 1993, as imports of frozen *sashimi* increased (140,000 to 190,000 metric tons) between 1988 and 1993 (Anon. 1994).

Fresh tuna consumption in Japan peaked at 133,000 metric tons in 1993 (Anon. 1994). It is not known if consumer preference for fresh tuna will continue, especially considering the limited shelf life (Tanabe, 1996). Domestic harvest of fresh tuna is holding relatively steady (65,000 to 70,000 metric tons /year), whereas fresh tuna imports increased dramatically from 1988 to 1994 (39,000 to 71,000 metric tons) and presently account for about half of the fresh tuna supply (Anon. 1995). Taiwan-flag longline fleets operating throughout the Indo-Pacific are the leading suppliers.

The average price for imported fresh yellowfin tuna has declined for the past two years. There was a marked slump in the Japanese bigeye tuna market during the first half of 1995 (Anon. 1995), although the price has since recovered. Currency exchange rates favor continued Japanese tuna imports from foreign sources with weaker currencies.

Declining prices may be due in part to an oversupply of medium to lower quality grade tuna. Another factor which might be affecting the demand and price of fresh tuna in Japan is the increasing use of alternative species, especially pole-and-line skipjack and albacore, for *sashimi* (Tanabe, 1996). This situation places a high priority on finding alternative markets for fresh tuna, especially medium to lower grades. Some marketers in Japan are emphasizing the potential of regional markets outside major cities (K. Kono, Toho Corp., pers. comm.).

4.2.4 Secondary Markets

4.2.4.1 Korea

Korea has been successful in developing a domestic market for *sashimi* tuna. The effort was initiated in 1991 in response to disappointing returns from tuna sales in Japan and the need to improve the economic viability of the Korean longline fleet. Currently, there are 140 *sashimi* restaurants and 100 *sashimi* home delivery businesses which are owned by Korean fishing companies. Annual consumption has increased to 20,000 metric tons (Choi, 1996).

Imports are reported to be of very small volume but are increasing (Choi, 1996). Korea may eventually represent a potential export opportunity if the demand continues to grow and the Korean fleet continues to diminish.

4.2.4.2 Latin America

Several Latin American nations are tuna producers but only in Venezuela is there a significant domestic market for fresh and frozen tuna. A market for canned tuna is developing in Mexico, which has a purse seine fleet. In both countries, domestic demand for tuna provides national fishing fleets with an option to export markets (San Miguel, 1996).

4.2.4.3 Europe

Most of the demand in England and the European continent is for low quality, cooking grade tuna. There is, however, increasing use of higher-grade fish, primarily for specialized cooking and secondarily for the small and ethnically specialized sashimi market. Most of the fresh tuna is imported as loins, but better quality fish is purchased in dressed (h&g) form. Tuna size and quality are less important than in other markets. Until recently, there was little differentiation between fresh and frozen tuna products.

5.0 WHY AND HOW ARE TUNA GRADED?

A description of tuna grading and its "bridging function" in linking sellers and buyers of fresh tuna was prepared from information provided by industry sources.

5.1 The Function of Grading

At least 50 countries are exporting fresh tuna and new producing areas continue to enter the market. Tuna buyers are presented with so much quality variation that it is common to inspect and grade fresh tuna prior to purchasing. Each fish thereby acquires an individual identity (i.e., a quality grade) which links it to possible end uses and market niches. Quality grades communicate a range of physical attributes of a tuna that is expected by the buyer. This identity is maintained throughout the distribution process as each level of the marketing network makes essentially the same set of quality evaluations.

Tuna grading provides a common language that simplifies communication between sellers and buyers and facilitates product sorting for different markets and end uses. Grading is also useful in market reporting, resolving disagreements about product quality and in providing performance feedback to harvesters.

Lack of grading experience or agreement can cause economic losses in two ways. If tuna is misgraded lower than its actual quality, losses are borne by the producers who could have sold the fish to higher-priced markets. In this case, buyers are unlikely to inform sellers of the error and will rarely offer to pay a higher price. The second possibility for misgrading is if low-quality tuna is sold, either intentionally or mistakenly, to customers expecting higher-quality fish. This scenario not only results in claims for credits or outright rejection of fish by the buyer but, more importantly, reduces the seller's credibility and the buyer's confidence.

5.2 Defining Tuna Quality Grades

Tuna grading decisions are guided by the intended use of the product. Associated with each type of use is a set of desired product characteristics. The grading process evaluates several questions of interest to tuna buyers:

—Is this fish the desired species? The physical characteristics of different species affect their suitability for various products and end uses.

—Is this fish the right size? Fish size affects product yields and physical characteristics, which may influence product acceptability and value.

—Who is the intended customer and what is the end use for the fish? Does it meet the physical requirements for the particular preparation and presentation intended?

Table 5-1 is the sequence of assessments made when tuna are individually graded.

TABLE 5-1. Tuna Are Individually Graded

1. Observable characteristics that affect market value	3. Muscle quality
Species	Texture
Size	Color
Body Defects	Clarity
2. Shelf life after purchase	Fat Content
Subjective evaluation of freshness, or usable life for intended end use	

5.2.1 Observable Characteristics

Table 5-2 summarizes the observable characteristics: fish species, size, and body.

5.2.1.1 Species

Bluefin tuna (*Thunnus thynnus*, *T. maccoyii*) are the most prized, and, hence, highest-priced, species of tuna in the Japanese *sashimi* market. Bluefin with high fat content can sell for astronomical prices, which are sometimes erroneously extrapolated to other tuna species and may generate unrealistic revenue projections. In January 1995, a 440-lb bluefin sold in the Tokyo fish auction for a record price of $114/lb.

TABLE 5-2. Grading Process 1: Observable Characteristics

A. Ranking of tuna species by usual fresh market value
bluefin tuna > bigeye tuna > yellowfin tuna > albacore tuna
B. Ranking of marlin species by usual fresh market value
striped marlin > black marlin > blue marlin
C. Large fish are generally worth more than small fish
Large > small
D. Fish body defects may reduce yield of usable muscle or shelf life
Shark bites Bruises and skin abrasions Gaff marks

Bigeye tuna (*Thunnus obesus*) is generally ranked second (after bluefin) in preference for *sashimi* in Japan and Hawaii but this species is not a major component of the continental U.S. fresh tuna market. Major worldwide markets exist for yellowfin tuna (*Thunnus albacares*), not only for *sashimi*, but also for cooking. In Japan, yellowfin is generally the third most popular species of tuna for *sashimi*, although regional preferences do exist.

Albacore tuna (*Thunnus alalunga*) is the premium species for canning, being the only tuna that can be labelled as "white meat" in the canned tuna market. The use of albacore in the Japanese *sashimi* market is increasing. In recent years, a grilling market for fresh albacore has developed in the U.S and there appears to be significant growth potential in the retail sector. Albacore muscle is paler and more fragile than yellowfin muscle but the former is sometimes substituted for yellowfin. Albacore is usually lower-priced and has longer shelf life. When both species are available, they are more distinctly separated in the market and yellowfin is the preferred species, even with a price differential, because the muscle has a deeper red color. Depending on their diet and area of capture, albacore may also have red muscle.

Several species of marlin are harvested incidentally in Pacific tuna fisheries and enter the same fresh fish markets as tuna. Although generally much paler than tuna muscle, marlin is served as *sashimi* in Japan and Hawaii, especially in large group catering, because the muscle discolors more slowly than tuna. Because of greater fat content, striped marlin (*Tetrapturus audax*) is the most highly regarded of the billfish species for use as *sashimi* as well as for cooking. The fat content of blue marlin (*Makaira mazara*) varies considerably with the area of harvest. This species is well liked for *sashimi* in the Kyoto-Osaka region of Japan but it is more commonly used in Japan and the U.S. for cooking and, in Taiwan, as a raw material in the processing of fish

cakes and fish balls. Black marlin (*Makaira indica*) has the same uses as blue marlin although some believe it is better tasting because of higher fat content.

5.2.1.2 Fish Size

The size of the fish (weight) is one of the factors determining product value. Large sizes are preferred by the market for several reasons. Large tuna yield more edible product than small tuna. Large loins produce a higher yield of premium cuts for *sashimi*, as well as larger dinner plate portions for the grilling market. Large tuna also have a tendency to have higher fat content, which increases the product value in the *sashimi* market.

Despite some variation in fish size classes, tuna purchasing in Japan, Hawaii, and the continental U.S. reflects a preference for larger fish. The exception is Europe, where there is a traditional preference for small fish.

In Japan,		In continental U.S.,		In Hawaii,	
>40 kg	g&g	> 80 lb	h&g	>100 lb	whole
25-40 kg	g&g	60-80 lb	h&g	80-100 lb	whole
15-25 kg	g&g	40-60 lb	h&g	50-80 lb	whole
<15 kg	g&g	20-40 lb	h&g	30-50 lb	whole
		<20 lb	h&g	<30 lb	whole

5.2.1.3 Body Defects

Evidence of past encounters with predators can be seen in the form of healed injuries or scars on the bodies of some tuna. Rough handling of tuna after capture may also cause body damage or skin abrasions. These defects may indicate more extensive damage to the underlying muscle layers. If the yield of usable muscle is likely to be affected, damaged tuna may be downgraded. Occasionally, white fibrous scar tissue is present in the deep muscle layers of tuna. This is the result of healed injuries from marlin spikes. Scar tissue is usually trimmed because of its unaesthetic appearance, although it presents no health hazard to consumers.

5.2.2 Shelf Life

"Freshness" is a common, but relatively ill-defined, term used in the marketing of perishable products. The objective determination of freshness is the "Holy Grail" of seafood technology. To date, no satisfactory objective measurement has been demonstrated or accepted by the fresh tuna industry.

A fisherman may produce a "fresh" fish, implying that it is in peak condition and only recently caught. If the fish has been poorly handled after capture (e.g., improperly chilled), a fresh fish could actually be at the end of its usable shelf life even if it is only hours out of the water. To the retail marketer, "fresh" may imply that the product is in peak condition, but in reality, the term only means that the fish has never been frozen. In practical terms, what is normally meant by tuna "freshness" is the anticipated shelf life for a *particular product and end use* that can be

expected from a fish. A combination of objective and subjective criteria are evaluated to make this assessment (Table 5-3).

TABLE 5-3. Grading Process 2: Evaluation of Shelf Life

A. Core temperature of fish
B. Body condition
C. Muscle texture and bloodline
D. Fishing, handling, storage methods
Longer shelf life allows for more marketing options. Shorter shelf life restricts marketing options and forces price discounting.

Each tuna has a usable shelf life that can be lengthened by good handling or shortened by poor handling. After the fish dies, the shelf life "clock" begins. The muscle changes from firm to soft, from red to brown, and from translucent to opaque. Even the highest grade of *sashimi* tuna will degrade over time to a lower grade suitable only for cooking. The same fish will deteriorate even further to a level of quality that may be wholesome and safe to eat but is no longer presentable on dinner plates.

Special procedures are recommended to preserve the quality of fresh tuna after capture to final sale (e.g., Nakamura et al., 1988) but there is strong evidence that the initial quality of fish is not uniform. The quality of tuna upon capture is affected by a wide range of biological and oceanographic factors, including swimming depth and ocean temperature, life stages and reproductive cycles of fish. It is generally believed that struggle (without an opportunity to recover from exercise) during capture is particularly detrimental to tuna flesh quality.
In order to assess the "freshness" of tuna, the buyer must know something about the product, how it was captured and handled post-capture. With such knowledge, experienced buyers can anticipate the usable shelf life of a tuna. It is generally accepted that the market value of a fresh tuna is determined largely by handling immediately after the fish is brought on board. The critical period of time is between landing and chilling the catch (using ice or refrigerated seawater) to a stable, internal (core) temperature of 0°C. Tuna should be maintained at this temperature throughout the storage, marketing and distribution process.

Tuna that is warmer than 0°C when marketed needs to be carefully scutinized. The fish has either been recently caught and is in the process of cooling down, which is not necessarily bad, or it has not been stored at the recommended temperature and the shelf life may have been greatly shortened as a consequence. In addition, if the temperature of the tuna being graded is not stable at 0°C, interpretation of muscle color can be very difficult because the pigments in tuna muscle which give it the desired red color are sensitive to temperature and oxidation.

In addition to checking core temperatures of fish, tuna buyers look for evidence that tuna were landed alive and were given individual care that prolongs shelf life:

- Evisceration of fish removes a major source of potential bacterial contamination and allows for accelerated chilling.

- Spiking or pithing the brain of a live tuna destroys the central nervous system and is believed to improve muscle quality and shelflife. Tuna that die on the line may be of poorer quality.

- Bleeding live tuna after capture aids in removing both a source of heat and an important medium for bacterial decomposition.

- Tuna bodies (rigor, post rigor), eyes, and gills are important indicators of freshness.

5.2.3 Muscle Quality

Evaluation of muscle quality is highly subjective because the critical characteristics (texture, color, clarity, fat content) vary along continuous scales (see Table 5-4). This dimension of grading is especially challenging because the grader only has access to a very small "window" or muscle sample on which to base his assessment of a whole fish. Sampling is accomplished by cutting a notch at the tail of each tuna to allow visual inspection of exposed muscle or by examining a small sample of deep muscle cored from the center of the fish. A third method, which is common in Hawaii, involves the visual and tactile evaluation of a small wedge of muscle removed from the tail. The grader is able to look closely at the muscle clarity and color. In addition, the grader can, by working the muscle sample between the fingers, determine if the color will "bloom" (become more red). The tactile evaluation also allows for an additional assessment of texture (firmness) and fat content.

TABLE 5-4. Grading Process 3: Evaluation of Muscle Quality

Characteristics that vary along a continuous scale:

A. Texture	Firm >>> Soft
B. Color	Bright Red >>> Brown
C. Clarity	Translucent >>> Opaque
D. Fat Content	Visible >>> Not Apparent

Visible, marbled fat, although uncommon in sub-tropical and tropical tuna and marlin, usually commands price premiums within all muscle quality grades.

One of the shortcomings of these grading methods is that muscle quality may not be uniform throughout the fish and the sample can give false readings. That is why it is important for the grader to make an assessment of how well the particular fish was cared for, as good handling and storage are more likely to produce uniform quality in the body of the tuna. Inconsistent quality within individual fish most often occurs when there is uneven cooling of the body or insufficient chilling and poor handling during storage. This is most often manifested in the thickest part of the tuna carcass, where the girth reduces the rate of chilling.

5.2.3.1 Texture

Muscle texture is an important factor in assessing the freshness of tuna. When the muscle deteriorates, it changes from firm to soft as muscle proteins are broken down enzymatically. Soft fish is difficult to slice into presentable and palatable *sashimi*. Excessively soft muscle is also difficult to use for grilling because it is hard to steak and prone to gaping (separation of the muscle segments).

5.2.3.2 Flesh Color

High quality tuna muscle is bright red. As the muscle deteriorates, its color changes from true red to brown red to red brown to brown and, finally, to black or dark grey. This process reduces the presentability or aesthetic quality of the product. Color is, therefore, one of the primary determinants of tuna muscle quality.

The red color is due to the blood and muscle pigments, hemoglobin and myoglobin respectively. These proteins serve as oxygen carriers and turn bright red when oxygenated. This explains why tuna muscle often "blooms" when exposed to the air. With time, the ability of the muscle pigments to bind oxygen decreases as the muscle pigments are oxidized to Met-myoglobin and Met-hemoglobin, which have a brown appearance.

5.2.3.3 Muscle Clarity

As high quality tuna deteriorates, the muscle changes from clear and translucent to opaque and dull. Translucent muscle is one of the aesthetic requirements for *sashimi*-grade tuna.

5.2.3.4 Fat Content

In some segments of the *sashimi* market, fat content is an extremely important factor in determining quality and price. Just as well-marbled beef is prized for its palatability, tuna with high fat content is in high demand in the Japanese and Hawaii *sashimi* markets because of its "melting" taste when eaten. Fat accumulates in tuna as in other animals. The belly muscles and peripheral or outer muscle layers are where fat is first deposited. In highly "conditioned" tuna, fat can be seen as marbling even in the deepest muscle layers.

5.3 Defining Marlin Quality Grades

Fresh marlin is less differentiated than tuna in market niches and associated quality requirements. Three general product types and grades are recognized:

No. 1: Raw products
No. 2: Upscale cooked products
No. 3: Smoked/fishcake products

Quality grading criteria for fresh marlin (Table 5-5) are generally same as for fresh tuna, although there is greater emphasis on the color and condition of the dark meat, or "blood line" portion of

marlin muscle. A bright red and narrow blood line indicates a fresher marlin than a dark and diffuse bloodline.

TABLE 5-5. Grading Criteria for Fresh Marlin

A. Species preference	Striped marlin > black marlin > blue marlin
B. Color of bloodline	Bright red > brown
C. Condition of bloodline	Narrow > diffuse
D. Clarity of flesh	Translucent > opaque
E. Fat content	Visible > not visible

5.4 Grading Decisions: Art Not Science

Fresh tuna is one of many perishable products for which there are no completely objective measures or definitions of quality. Tuna grading systems attempt to standardize what is a highly subjective process. An analogous product is graded beef. Guidelines for the amount of fat and muscle color in meat are well defined but meat inspectors grade carcasses based on a consideration of subjective criteria as well as quantifiable measurements.

Except for species, weight and core temperature, there are no objective measurements used in tuna grading. Hence, grading remains more an art than a science. Graders can easily observe the condition of tuna bodies but they can directly sample only a small section of the fish muscle. Grading proceeds rapidly from fish to fish and graders have only a few seconds to integrate their evaluations and assign a grade during purchasing, processing and export operations.

6.0 CALIBRATION OF TUNA GRADING STANDARDS IN MAJOR MARKETS

A combination of characteristics places each tuna in a quality grade. This grade is not a fixed point but a *flexible range of qualities* that are acceptable within a particular market niche and consumer application. The objective of proper tuna handling is to extend shelf life and prevent rapid change in physical qualities outside the original range.

Tradeoffs in qualities are unavoidable. The bright red, translucent muscle of the bigeye tuna can sometimes be so soft that it is unusable for *sashimi*. Flaws in firmness, color and translucency can be overlooked in favor of high fat content, raising the grade and price of a fish that otherwise might not qualify. The ultimate decision rests on whether a particular fish is suited for a particular end use.

Communication about the physical characteristics of fresh tuna is facilitated by referring to quality grades. "Calibration" of grading standards is often necessary to match buyers' expectations with sellers' product specifications. A mutual understanding of grades evolves with ongoing trade and interaction. Hence, grading is influenced by relationships and communication between buyers and sellers, as well as by the physical attributes of tuna.

The following description of tuna quality grades represents the perspective of the Hawaii market, based upon the investigators' practical knowledge of product requirements and confirmed in interviews with wholesale buyers and end users.

6.1 Tuna Quality Grades Recognized in Hawaii

At least five grades of tuna are recognized in Hawaii. Their relationship to various products and end uses is defined in Figure 6-1.

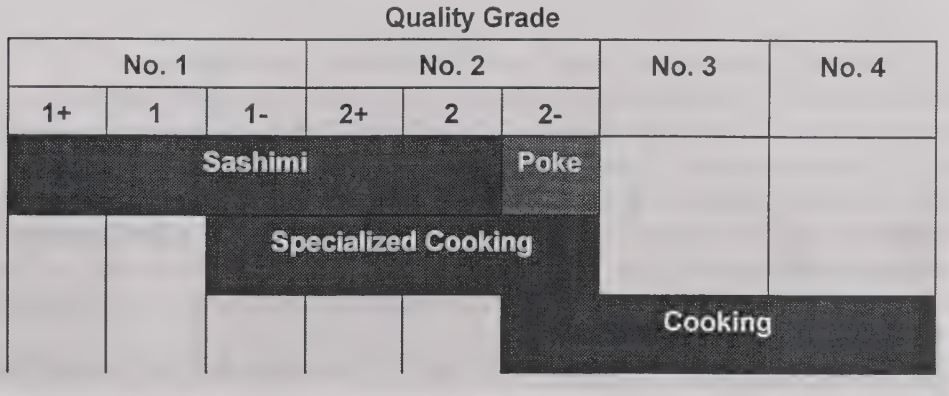

Figure 6-1. Relationship between fresh tuna grade and end use in Hawaii.

6.1.1 Grade No. 1+ (A+, XXX)

A tuna with all of the desirable characteristics is uncommon: large, fresh, firm fish with muscle that is bright red, highly translucent and has high visible fat content. This grade is used only in the most discriminating, highest-priced restaurants and *sushi* bars in Japan. Grade No. 1+ cannot command its full value anywhere else in the world.

6.1.2 Grade No. 1 (A, XX)

This grade is the standard, high-quality *sashimi* tuna—large, fresh and firm with muscle that is bright red and highly translucent, but little or no visible fat content. This grade includes fish quality ranging from the standard *akami* (red meat *sashimi*) to higher-quality *sashimi* with slight fat content. Grade No. 1 has a limited market outside of Japan and Hawaii that is willing to pay comparable prices. In the continental U.S., only *sushi* bars and upscale restaurants can afford to use this grade of tuna.

6.1.3 Grade No. 2 (B, X)

This is considered the affordable or medium grade of *sashimi* tuna, equivalent to the Japanese Grade B. The fish is fresh and firm, with muscle that is red to red-brown color but lacking the translucency of higher-quality tuna. Although this grade satisfies most of the requirements for *sashimi*, it does not quite meet the aesthetic requirements (i.e., muscle clarity) of the No. 1 or Grade A, so it is not used by *sushi* bars with discriminating clientele. Many other market niches are satisfied with Grade No. 2 tuna. At the higher range of this quality grade is the No. 2+ sub-grade, which is widely used for *sashimi* and is priced between the No. 1 and No. 2 grade. At the lower range is the No. 2- sub-grade, which is mostly cooked but is important in the Hawaii market for *poke* (raw fish cubes with relishes).

6.1.4 Grade No. 3 (C)

The normal Grade No. 3 has muscle that is too brown, too pale, or too soft for any use but cooking in preparations that mask the lower quality of the product. Another component of fish within the No. 3 grade is tuna which are simply too small (< 35 lb h&g) for the mainstream market but which may have good enough muscle color for raw fish or upscale cooking. The No. 3 is not usually exported by Pacific island producers, although there are markets in areas of the U.S. mainland and in Europe.

6.1.5 Grade No. 4 (D)

This grade of tuna is generally unsatisfactory for any use except canning. Fish are often damaged, soft or they have discolored muscle. Many buyers recognize a higher sub-division (4+ or 3-) within this grade if the muscle is very pale but not completely brown or opaque. Processors with access to a large supply of No. 3 tuna sometimes manufacture value-added products, including frozen tuna loins, smoked and dried tuna products.

6.2 Tuna Quality Grades in Other Markets

Hawaii's quality standards for fresh tuna cannot not be directly compared to those in other major markets without some "calibration" of grading systems. The investigators participated in commercial grading of tuna in the Gulf of Mexico, the U.S. West and East Coast, Guam and Micronesia, Tonga and Oman during the course of this study. There were also opportunities to grade small amounts of fresh tuna from the Philippines, Indonesia, Ecuador, Mexico, and the Marshall Islands while the investigators visited tuna buyers in major markets.

Key industry informants were selected in Hawaii, San Francisco, Los Angeles, Houston, New Orleans, Boston, New York, Japan, and major European cities. They provided information through personal interviews, which were open-ended and not structured by a formal survey instrument. The interviews focused on comparing the grades of tuna, as represented by suppliers in Hawaii, the continental U.S. and overseas, with the quality requirements of specific markets and end uses. The industry contacts developed for the calibration exercise also served as primary sources of market information for Section 8.

6.2.1 Japan

The Hawaii grading scale of No. 1, 2 and 3 is essentially equivalent to the Japanese system of A, B and C. Graders need to recognize the grades of tuna which can be profitably shipped to Japan and to separate them from fish of lesser quality. Before shipping, exporters should determine if the expected price justifies export. Close communication with Japanese companies which specialize in fresh tuna import is advisable to forecast market conditions at least two days in advance of shipment.

6.2.2 Continental U.S.

6.2.2.1 Gulf of Mexico

The Gulf of Mexico yellowfin tuna fishery experienced rapid growth during the 1980s. Most of the fishing activity was based out of Florida, Louisiana, and Texas. Many of the vessels have since left the gulf to join longline fisheries in Hawaii and elsewhere.

Attrition in the U.S. longline fleet has increased competition among unloading docks for the remaining vessels which unload at U.S. ports. Unlike the situation in Hawaii, where the majority of tuna landings are sold through an auction system, in the Gulf of Mexico private dock owners unload fishing vessels and seafood wholesalers must work with dock owners to acquire fish.

In the mid-1980s to the early-1990s, the gulf tuna fishery set the standards for tuna grading and pricing in the US domestic market and represented the principal competition for Hawaii's fresh tuna exports. In the early years, gulf tuna produced by longliners was often sold by boat loads or "boat runs". The reputation of the fishermen and the vessel for producing good quality fish had to be known in order to determine what price to pay. The percentages of No. 1, 2, and 3 fish had to be estimated by buyers based on past experience with the vessel, the captain and crew. In general, prices were bid at slightly over the buyer's estimate of the going market price of the No. 2 grade. Increasingly, boat loads are fully graded and each fish is sold on its own quality merits after the price for the grades is negotiated.

As a result of increased competition for the gulf tuna, there is presently a tendency for overgrading of tuna by the dock operators to help the vessels in selling to the wholesalers. Re-grading by wholesalers is required and it is common for them to absorb the cost of downgrading 10% of a boat load of tuna. Gulf wholesalers find this situation detrimental. They are exploring alternative sources of fresh tuna and diversifying into other products. Through this process, many gulf wholesalers have become importers of fresh tuna.

Gulf tuna are shipped into U.S. markets from coast to coast. Prices for gulf tuna are always settled hours before Hawaii fish auctions begin. Thus, the gulf fishery often determines price ceilings that Hawaii exporters face in the U.S. tuna market.

6.2.2.2 East Coast

As the domestic fresh tuna market continues to expand in the U.S., so does the volume of imported tuna. In recent years, there has been a remarkable increase in fresh tuna imports

entering the country through Miami. Longline fishing is developing rapidly in South and Central America and the Caribbean, with Ecuador, Venezuela, Trinidad, and Costa Rica tuna becoming increasingly common in the market. Imports are also entering the East Coast market from an Indian Ocean yellowfin tuna fishery based in Oman.

The cost of ground transportation from Miami to New York is significantly cheaper than air freight from the gulf unloading stations. Consequently, imports in the New York market are often priced $0.25 per lb less than gulf tuna.

On the Atlantic coast, fresh tuna is landed principally by longliners, but purse seine fishermen who normally sell yellowfin tuna catches for canning are competing in certain fresh tuna markets with a portion of their better quality catch (J.J. Hoey, Blue Water Fishermen's Association, pers. comm., 1994).

6.2.2.3 West Coast

Increasing dependence on imported tuna is displacing gulf tuna from the East Coast grilling market. Gulf producers are shifting marketing emphasis to the West Coast, where the major competition is from Hawaii and other Pacific basin suppliers. West Coast buying standards for No. 2 tuna are rising, so quality/price relationships will be scrutinized more closely in this market.

Twelve longliners recently relocated to California from the Gulf of Mexico to enter the eastern Pacific swordfish fishery, which is based in Ventura county. Seasonally, this fleet also catches fresh tuna, which enters the Southern California market through an auction. In San Pedro, several small purse seiners are landing bluefin tuna between July and September. These fish are of marginal quality and, consequently, they are offered at very low prices.

6.2.2.4 Middle America

Buying standards for grill-grade fresh tuna are rising in the Rocky mountains and Great Lakes regions. In much of the southeast, northeast and midwest, however, tuna with pale muscle color (No. 2- or 3+) is still readily acceptable. This same grade of fish is becoming increasingly unacceptable to West Coast tuna buyers.

6.3 Calibration of Tuna Grading Systems

U.S. mainland importers of Hawaii tuna indicated that grading standards in Hawaii are generally consistent with the quality expectations of their markets. They indicated a preference for Hawaii yellowfin and observed that Hawaii bigeye are often downgraded for soft texture.

In Hawaii, the No. 1 grade requires red muscle with high transparency and firm texture. In the rest of the U.S. market, muscle color alone is much more important. In the Gulf of Mexico, typical longline boat loads reportedly produce over 50% No.1 grade tuna. This extremely high percentage was attributed to the grading emphasis on color attributes alone. Furthermore, the Gulf No.1 grade may include muscle with light red color if it has high clarity and firm texture.

High-standard grading may explain why Hawaii No.1 tuna is often priced much higher than Gulf No. 1. Premium fish may command prices far above average because they are sold individually in Hawaii's fish auctions. Many buyers in the U.S. who would like to serve *sashimi* are discouraged by the high prices of true No. 1 grade tuna. This has created a demand for and the further breakdown of the No. 2 quality grade. The so-called "No. 2+" is the *sashimi* of choice for most of the U.S. because of its value. The most important attribute in this market is red muscle and the No.2+ can provide this while falling short of the No.1 grade in other attributes, especially muscle clarity.

Gulf of Mexico tuna grading also differs from Hawaii practices in that the fish under 60 lb dressed weight are not graded before sale. In Hawaii, all sizes of tuna are graded for muscle quality. Size classes in the Hawaii tuna market match the gulf breakdown, but the diversity of fresh tuna products in Hawaii provides an incentive to grade each fish to obtain the best price available.

Except for differences previously discussed, Hawaii, Japan and the continental U.S. buyers generally concur on the grading of fresh tuna (Table 6-1). Grade No. 2 tuna was found to be the most consistently graded in these major markets. Fresh tuna is exported by at least 50 different countries but only a few sources are consistently satisfactory in grading (Table 6-2). Others consistently overrepresent the grade of their tuna exports. A third group is accustomed to supplying the less sophisticated fresh tuna market in Europe and grading for the U.S. market is inconsistent. A fourth group may be only concerned with marketing high volumes of tuna without individual fish grading. Not surprisingly, no cases were reported of suppliers consistently undergrading or underrepresenting their tuna quality.

TABLE 6-1. Comparison of Fresh Tuna Grading Systems in Hawaii, Gulf of Mexico, Japan

US Domestic	Hawaii	Gulf of Mexico	Japan
No. 1	No.1+ No.1 No.1-	No.1	Grade A
No. 2	No. 2+ No. 2 No. 2-	No. 2+ or 2a No. 2 or 2b No. 2- or 2c	Grade B Grade C
No. 3	No. 3	No.3	Reject
No. 4	No. 4	No.4	Reject

TABLE 6-2. Comparison of Grading Ability of Selected Fresh Tuna Exporting Countries

Grading generally consistent with U.S. market.	Fiji Australia
Most improved grading.	Ecuador
Consistently over-represent grade.	Philippines Venezuela Costa Rica Indonesia Malaysia Micronesia
Supply European market; learning U.S. grading system by trial-and-error.	Oman Brazil Azores Sri Lanka
Volume suppliers without apparent concern for grade.	Trinidad

6.4 Color Chart: A Tool for Calibration

Disputes over quality grades are commonplace in fresh tuna marketing and they are accepted as a necessary part of doing business. Both sellers and buyers could benefit from a less subjective and more standardized system of tuna grading that would allow a better comparison of products from various source areas. However, codification of tuna grade specifications has been deemed impractical by some, because of the inherent difficulty in relating written descriptions to actual physical characteristics (Williams, 1986). This is especially true of tuna muscle color.

As part of the present study, a color chart (enclosed with original report only) was developed and tested as a tool with potential for standardizing the most subjective dimension of tuna grading -- muscle color. The color scheme was designed to represent the changes in tuna muscle pigments which occur during normal post-mortem deterioration.

Initial response to this color chart by the fresh tuna industry has been mixed. Graders who were interviewed described the color scheme as being close to the natural range of tuna muscle color as it deteriorates from bright red to brown. The tool helped to reveal differences between continental U.S. and Hawaii markets in defining acceptable color in grade No. 1 tuna. Hawaii standards were confirmed to be stricter. Some graders in the U.S. mainland observed that the scale of color was incomplete because the chart did not represent the brown to gray to black range at the lowest end of the quality spectrum.

Other tuna grading charts have relied upon photographs to represent fresh tuna grades (Williams, 1986 and QFITC). The basic weakness of this approach is that grading is based upon "snapshots" rather than on a continuous color scale. The salmon industry has developed charts (*Color Evaluation Guide to Pacific Salmon*, Alaskan Salmon Marketing Institute) meant to represent the variety of colors found in salmon species and qualities. This approach is better than snapshots at accounting for variation in muscle color. The drawback of these examples is that they do not depict a continuous color scheme. The chart presented in this study is the first application of a continuous color scheme in the grading of fresh tuna muscle.

Based on preliminary testing of the tuna color chart, the tool has potential to improve mutual understanding of muscle color grading between buyers and sellers. It may serve as a training tool for graders and quality control personnel but it will not replace the practical experience needed to become proficient in tuna grading. Such a tool will also not supplant the effort needed to create and maintain effective communication between buyers and sellers, although it may be useful to both parties as they describe color qualities.

Muscle color is the most heavily weighted grading criteria in many fresh tuna markets but it is not the only one. Muscle clarity or transparency, texture, and a perception of the overall "freshness" and remaining shelf life are very important and cannot be evaluated using a color chart.

6.5 Elasticity of Grading Standards

Both sellers and buyers expect the price of fresh tuna to fluctuate in response to cycles of supply and demand. If quality grades are mutually satisfactory to buyer and seller, grading should, ideally, not be affected by supply and demand. The reality is that quality grades are supply sensitive. Standards are more relaxed when supply is low and more demanding when supply is high.

The elasticity of grades causes confusion in fresh tuna marketing, especially to fishermen trying to interpret dockside prices. When low supply and strong demand combine, inferior quality tuna that would normally be rejected for the *sashimi* market may be profitably exported. Conversely, when low demand and high supply create weak market conditions, it may be unprofitable to sell even better quality fish for *sashimi*.

7.0 PRICE DETERMINANTS OF FRESH TUNA IN HAWAII MARKET

The hypothesis that differentiated markets and associated quality requirements are primarily responsible for fresh tuna price variability was evaluated quantitatively in Hawaii.

7.1 Major Variables

Sales at the Honolulu fish auction were sampled to define relationships between average unit price ($/lb) and fresh tuna and marlin characteristics:

- Fish species
- Fish size
- Fish harvesting method
- Fish quality grade

These are believed by industry sources to be the major determinants of fresh tuna price variability on a daily basis. Superimposed on short-term price variability are fluctuations which industry sources believe are related to fish supply and demand. The present study makes no attempt to quantify the latter relationships. Previous studies have found it difficult to determine statistically-significant relationships between the quantity of tuna supplied and price in the Hawaii market (Pooley, 1990; Pooley, 1991). According to industry observers, a deterioration in Hawaii's economy has caused tuna pricing to be more sensitive to supply than in the past.

No price data were collected for skipjack tuna, although this species dominated the Hawaii tuna market until the late 1980s. Reduction in the pole-and-line fleet which harvested skipjack and expansion of the longline and handline fleets have made bigeye, yellowfin, and albacore tuna the dominant species of fresh tuna in the contemporary Hawaii market. In recent years, the Hawaii-based longline fleet has begun to harvest bluefin tuna on a seasonal basis, with approximately 60,000 lb landed in 1994. Bluefin tuna are not caught off Hawaii in the summer and no sales were sampled in this study.

7.2 Data Base

7.2.1 Honolulu Fish Auction Sampling

Detailed sets of data associated with wholesale tuna and marlin transactions in the Honolulu fish auction were collected during two sampling periods: June 30-July 14, 1994, and June 22-July 8, 1995. Market sampling was scheduled for summer because this is when the three commercial tuna fishing fleets—longline, handline, and troll—supply the market and interact.

Table 7-1 lists the types of information collected for each tuna and marlin sale. Data were recorded for over 2,500 tuna transactions in 1994 and over 6,000 tuna transactions in 1995 (shown by species and sample period in Figure 7-1). The data base also includes information for 830 marlin transactions in 1994 and 980 marlin transactions in 1995 (shown by species and sample period in Figure 7-2).

TABLE 7-1. Types of Data Collected During Market Sampling

Listing of database structure:

Number	= Record number
Grader	= Person grading fish
Location	= Geographical selling location
Date	= Date of transaction
Dataset	= Dataset number
Boat	= Name of vessel where fish came from
Gear	= Gear type of vessel
Species	= Fish species
Grade	= Grade of fish 1,2,3,4
Grade2	= Grade subdivision +,-
Burn	= Burn level 0,1,2,3
Fat	= Fat present T,F
Damaged	= Damage indication T, F
Soft	= Soft indication T,F
Form	= Form of fish when sold
Weight	= Weight of fish in above form
Sell price	= Price fish sold for
Whole weight	= Converted whole weight

Table 7-2 compares the 1994 and 1995 sample periods in terms of tuna and marlin supply characteristics. Longline landings, especially of bigeye and albacore tuna, were much larger in 1995 than in 1994. Troll landings of yellowfin tuna were greatly reduced in 1995 compared to 1994 but blue marlin landings were up.

TABLE 7-2. Comparison of Hawaii Market Sampling Periods

Species	Fishing Method	1994 Landings (lb)	1995 Landings (lb)	% Difference
Yellowfin tuna				
	Longline	85,831	137,652	+ 60.4%
	Handline	55,608	49,559	- 10.8%
	Troll	49,122	10,362	- 78.9%
Bigeye tuna				
	Longline	44,970	132,293	+ 194.2%
	Handline	2,716	2,189	- 19.4%
Albacore tuna				
	Longline	27,258	160,956	+ 490.5%
	Handline	5,783	1,852	- 68.0%
Blue marlin				
	Longline	42,379	70,667	+ 66.8%
	Troll	6,698	16,363	+ 144.3%
Striped marlin				
	Longline	30,424	42,115	+ 38.4%

Average wholesale prices were derived for each tuna and marlin species—by fish size, harvest method, and quality grade (Tables 7-3A and 7-3B). Testing of variance between values for 1994 and 1995 sample periods showed that the two data sets were not statistically different.

7.2.2 Neighbor Island Market Sampling

The Honolulu auction is not the only marketing channel for fresh tuna. During market sampling, significant quantities of handline-caught yellowfin and bigeye tuna and troll-caught yellowfin tuna were sold through the Hilo fish auction or directly to wholesalers on the islands of Hawaii and Maui. Information was collected from major tuna distributors summarizing daily sales of fresh tuna by species, size class, harvesting method and quality grade.

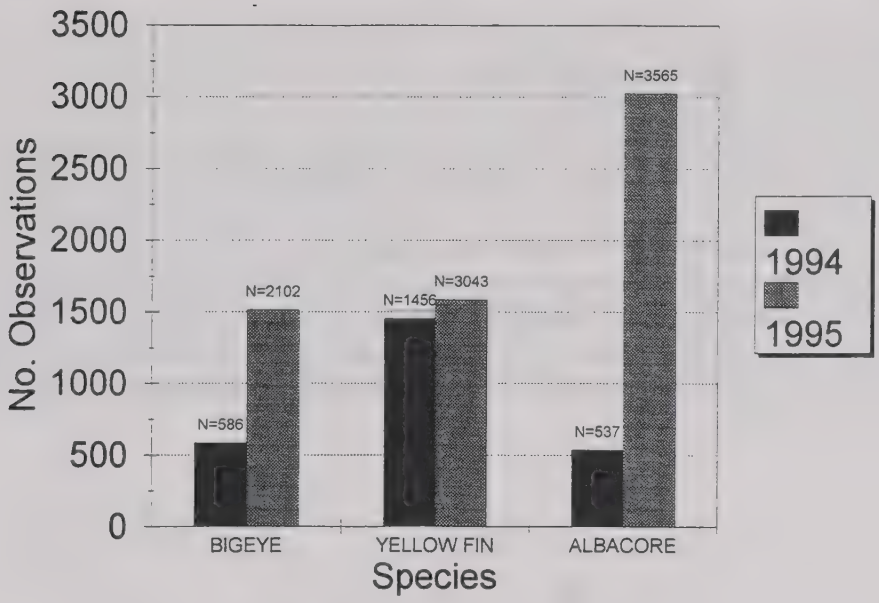

Figure 7.1. Hawaii market observations by species and sample period.

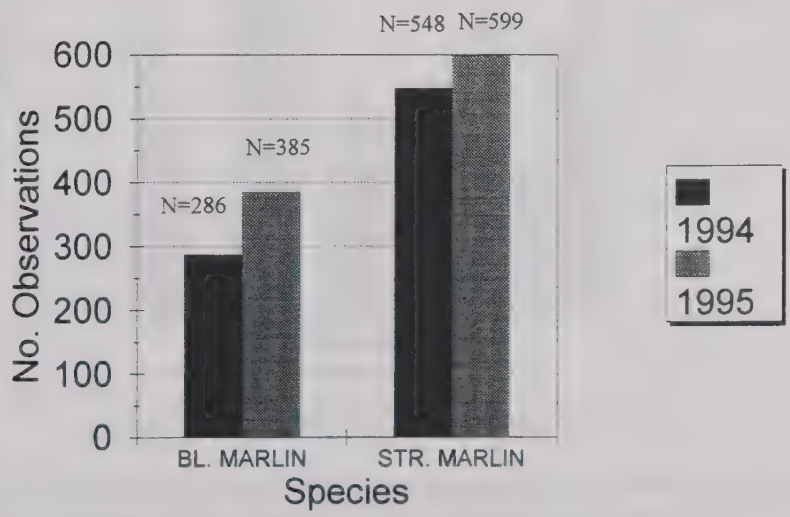

Figure 7-2. Hawaii market observations by species and sample period.

7.2.3 Unsampled Markets

Some yellowfin tuna harvested by troll fishermen during the study were sold outside of regular commercial marketing channels. The quantity could not be reliably estimated but is not believed to comprise more than 5% of commercial yellowfin landings during market sampling. Interviews with trollers suggested that average prices received from such transactions during the 1994

sampling period were $0.80-1.00/lb below the Honolulu auction average return for troll-caught yellowfin tuna.

7.3 Price Variation by Fish Species and Size

Using the Honolulu auction data base, average unit prices ($/lb) were calculated by fish species and size class (Figure 7-3). There is a strong market preference for bigeye and yellowfin tuna, evidenced by average prices that were $0.50/lb to $1.00/lb more than those for albacore tuna or marlin. The data also indicate that, for single species, there is a price premium for fish larger than 60 lb (whole weight). The premium was small for albacore tuna and marlin but was much larger ($0.50-1.00/lb) for bigeye and yellowfin tuna over 60 lb. These findings are explained by the stratification of Hawaii's tuna market. The high-priced, *sashimi* market places a premium on large, red-muscled tuna (bigeye, yellowfin). Smaller fish with pale muscle color enter different, lower-priced market niches.

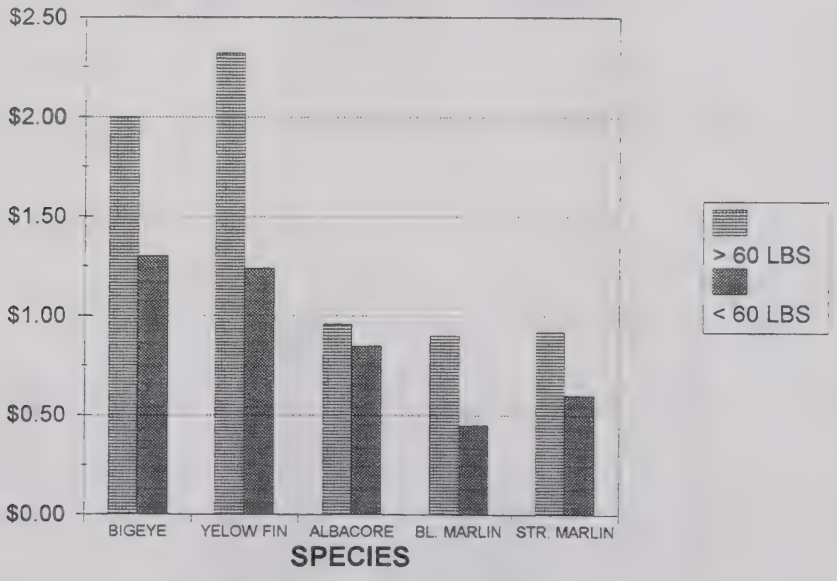

Figure 7-3. Average price by fish species and size.

The average price for yellowfin tuna was higher than for bigeye tuna during the summer market sampling. This reverses in the winter months, when bigeye tuna commands a substantially higher average price. The seasonal variation is related primarily to changes in fish quality characteristics and it is not strictly a species preference. When grade No. 1 tuna alone are considered, bigeye commands a higher average price than yellowfin year-round.

7.4 Price Variation by Fishing Method

Hawaii's commercial tuna fishery is heterogenous in terms of boat size, gear type, frequency of fishing activity, and dependence of harvesters on fishing for a livelihood. One of the reasons for this diversity is the State of Hawaii licensing and catch reporting requirement which defines a "commercial" fisherman as anyone who sells even one fish. Three major gear types—longline, handline and troll—compete within the same basic Hawaii marketing framework, which is well described by Pooley (1993).

Average price relationships between species and harvesting methods were calculated from the Honolulu auction data base (Figure 7-4). Harvesting method had little apparent effect on the average price of striped marlin or blue marlin. The average price of handline-caught albacore was about $0.40/lb higher than for longline-caught fish; this sub-surface species is not taken by trollers.

Figure 7-4. Average price by gear.

Yellowfin tuna is taken by all three gear types. The average prices for troll and longline yellowfin were almost equivalent but handline-caught yellowfin received $0.50/lb more. Bigeye tuna was the only species for which the longline fishing method produced a higher average price—$0.80/lb more than for handline fish. Bigeye is a subsurface species not captured by trollers.

Pooley (1990, 1991) undertook a brief examination of market interactions between longline and non-longline components of the Hawaii pelagic fishery but determined that the evidence concerning the relationship of longline to troll/handline sales was inconclusive because of limited information on exports.

The extent to which there is market competition among the different gear types remains in question but harvesting method alone does not explain short-term tuna price variability. Careful scrutiny of the major gear types revealed that they could be further subdivided according to specific details of their fishing strategies. For example, some longline fishing incorporates elements of the handline method and some handline fishing adapts from trolling practices. Substantial variation in shipboard fish handling and storage also defies simple categorization by major gear type.

7.5 Price Variation by Fish Quality Grades

Tuna quality gradations provide the most satisfying explanation of price variability because the effects of specific harvesting, handling and storage practices are integrated. During Hawaii market sampling, each tuna and marlin was graded prior to sale. Selling prices were later recorded as fish were auctioned.

The grades (No. 1-4) conform to the specifications discussed in Section 6.1. Grading was performed following the standard practice of Hawaii tuna buyers. Two of the investigators are recognized within the industry as highly experienced tuna graders. They did not require any special training for this task.

Figure 7-5 presents the grade composition by species. The majority of tuna and marlin were graded No. 2: from a low of 43% of striped marlin to a high of 79% of albacore tuna. The second largest group of fish were in the No. 3 grade: from a low of 17% of albacore tuna to a high of 52% of striped marlin. Few fish qualified as No. 1 grade: less than one percent of albacore to a high of 6% of yellowfin. The percentage of No. 4 grade was also low, except for very poor quality bigeye tuna (11%).

The average price for bigeye and yellowfin tuna varied substantially with the quality grade, as presented in Figure 7-6. The price premium for No. 1 grade was $2.00-2.50.lb higher than for No. 2 grade. The No. 2 grade received over $1.00/lb more than the No. 3 grade. The difference in average price between No. 3 and No. 4 grades was small. No. 1 bigeye averaged higher prices than No. 1 yellowfin but the price for No. 2, No. 3 and No. 4 grades was nearly the same for the two species. Average price varied much less among different grades of albacore tuna and marlin.

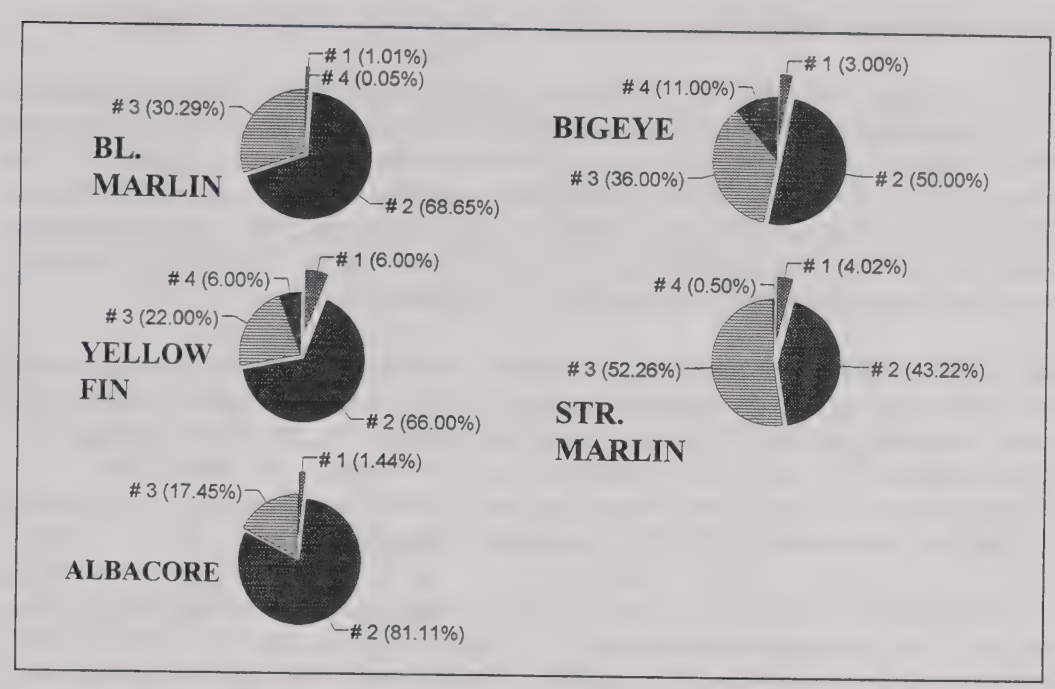

Figure 7-5. Grade composition by species.

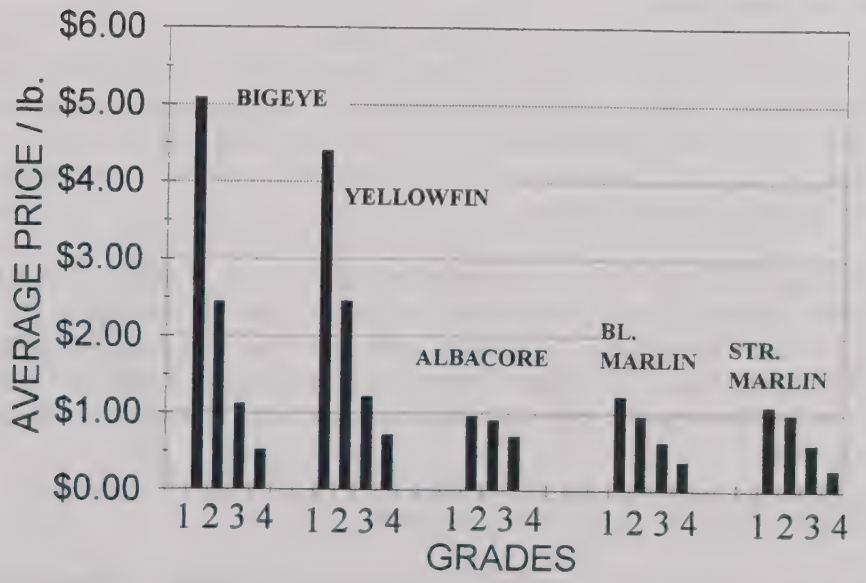

Figure 7-6. Average price by species and grade.

7.6 Grade/Gear/Price Relationships

Much of the tuna price variability that is associated with harvesting method (Section 7.4) can be explained by considering grade composition. The average price for longline-caught bigeye tuna was higher than for handline-caught fish because 55% of the longline bigeye was grade No. 2 or better, whereas only 3% of the handline fish was above grade No. 3. Handline-caught yellowfin tuna received a higher average price than longline or troll fish because 90% of the handline fish were grade No. 2 or better, compared to 62% of longline fish and 24% of troll fish. A summary of grade composition by fish species and gear type is given in Table 7.3a.

Quality gradations define price variability in the Hawaii tuna market better than fishing method. In general, the average price of fresh tuna is remarkably similar within each quality grade, regardless of harvesting method. For example, troll-caught grade No. 2 yellowfin averaged $2.26/lb, compared to $2.59/lb for No. 2 handline-caught yellowfin and $2.46/lb for No. 2 longline-caught yellowfin. No. 1 grade bigeye tuna sold for an average price of $4.60/lb when landed by longline vessels and for $4.18/lb when landed by handline vessels.

Table 7-3b demonstrates these relationships, as well as revealing three exceptions that require more scrutiny. The first exception is that grade No. 1 yellowfin tuna caught by trollers sold for an average of $2.81/lb, considerably lower than for other gear types. This can be explained by differences in handling by the Honolulu fish auction. Longline and most handline tuna are marketed in whole or dressed form during the first round of the auction. Troll-caught tuna are prone to quality problems (especially "burn") that are difficult to detect, so one quarter is removed to reveal the muscle. Once tuna are quartered, buyers lose marketing options that are available for whole or dressed tuna.

A second exception found in Table 7-3b involves the substantial difference in the average price of longline and handline No. 2 bigeye tuna. When questioned about this, auction buyers said that they lacked confidence in the shelf life of handline-caught bigeye. They noted that fish that initially appear to be No. 2 quickly deteriorate to No. 3. Thus, export of handline-caught bigeye was not considered a viable marketing option.

The third exception seen in Table 7-3b is the higher average price of No. 3 and No. 4 yellowfin tuna caught by trollers compared to the price of longline and handline No. 3 and No. 4 fish. Much of the purchasing of these grades is by peddlers seeking low-priced product for immediate sale. Grade No. 2 is too expensive for them and, when choosing from No. 3 and No. 4 fish, they select troll-caught yellowfin because of its greater freshness compared to longline and handline fish of equivalent grades.

8.0 INTERCONNECTION OF MAJOR TUNA MARKETS

Fresh tuna has become a globally traded commodity. This was made possible by improvements in air transportation and telecommunication. Any single producer or producing area represents only one of many potential sources of fresh tuna. Unlike many producing areas, Hawaii has a strong domestic demand for fresh tuna and export is only one marketing option. The present study investigates the extent of market connectedness by comparing Hawaii tuna prices with those in major export markets.

Table 7-3A. Summary of Hawaii Market Survey Data 1994 & 1995

	Average Price			Size Comparison		Percent Occurrence Grades			
	Price	S.D.	N	>60 lbs	<60 lbs	1	2	3	4
Yellowfin	$2.21	1.24	3043	$2.32	$1.24	6.0%	66.0%	22.0%	6.0%
Bigeye	1.84	1.47	2102	2.00	1.31	3.0	50.0	36.0	11.0
Albacore	0.89	0.39	3565	0.96	0.85	0.4	79.0	17.0	0.0
Blue marlin	0.88	0.38	833	0.88	0.45	1.0	68.0	30.0	0.5
Striped marlin	0.81	0.62	984	0.92	0.60	4.0	48.0	52.0	0.5
Yellowfin									
Longline	$2.11	1.35	1800	$1.14	$2.20	6.6%	59.0%	25.7%	8.5%
Handline	2.55	1.13	730	0.95	2.64	7.5	83.0	8.5	1.0
Troll	2.05	0.79	512	1.42	2.26	3.9	19.7	26.5	1.8
Bigeye									
Longline	$1.88	1.5	1975	$1.37	$2.00	3.4%	52.0%	32.8%	11.4%
Handline	1.07	0.49	122	0.98	1.50	0.0	3.2	90.0	6.5
Troll	0.00	0	0	1.42	2.26	0.0	0.0	0.0	0.0
Albacore									
Longline	$0.87	0.38	3416	$0.83	$0.96	4.2%	77.9%	17.9%	0.0%
Handline	1.26	0.31	149	1.10	1.29	0.7	97.3	2.0	0.0
Troll	0.00	0	0	0.00	0.00	0.0	0.0	0.0	0.0
Blue marlin									
Longline	$0.88	0.38	719	$0.42	$0.89	2.0%	67.0%	31.0%	0.6%
Handline	0.78	0.21	4	0.00	0.78	0.0	50.0	50.0	0.0
Troll	0.93	0.34	112	0.80	0.93	0.0	79.0	20.0	0.9
Striped marlin									
Longline	$0.81	0.63	967	$0.59	$0.92	4.2%	42.0%	53.0%	0.7%
Handline	1.60	0	1	1.60	0.0	0.0	100.0	0.0	0.0
Troll	1.02	0.43	16	0.74	1.19	13.0	75.0	13.0	0.0

Table 7-3B. Summary of Hawaii Market Survey Data 1994 & 1995

Species	Gear Type	Grades 1	2	3	4
Yellowfin	Longline	$4.60	$2.46	$1.14	$0.71
	Handline	4.18	2.58	1.06	0.21
	Troll	2.81	2.24	1.54	1.20
Bigeye	Longline	5.08	2.45	1.12	0.05
	Handline	0.00	1.58	1.11	0.30
	Troll	0.00	0.00	0.00	0.00
Albacore	Longline	0.97	0.90	0.71	0.00
	Handline	1.10	1.27	0.97	0.00
	Troll	0.00	0.00	0.00	0.00
Blue marlin	Longline	1.11	1.00	0.61	0.23
	Handline	0.00	0.90	0.65	0.00
	Troll	0.00	1.02	0.59	0.50
Striped marlin	Longline	1.24	0.98	0.64	0.38
	Handline	0.00	0.00	0.00	0.00
	Troll	1.15	1.04	0.80	0.00

The difficulty is in standardization of tuna quality grades. Once a standard product is defined, it is a simple matter to examine the basic economic relationship:

If, $P_i - P_j < t_{ji}$ there is no trade from j to i, and

If, $P_i - P_j \geq t_{ji}$ there can be trade from j to i

where P_j is the price in market j and t_{ji} is the unit cost of shipping between market j and market i.

Given that trade takes time, the equation should probably be

If, $E(P_i)-P_j = t_{ji}$ then there can be trade and E is the expected value operator.

What is required is data on the prices in different markets for the same commodity at similar points in time, the unit transportation cost between markets, and the pattern of commodity flows between markets over time. This information was collected from tuna industry sources in Japan and the continental U.S. for time periods that coincided with Hawaii market sampling.

Fresh tuna is exported in various product forms. The Japan tuna market generally prefers fish dressed with the head on ("gilled and gutted", g&g), whereas the continental U.S. market buys dressed fish with the head off ("headed and gutted", h&g). Whole tuna are the standard in Hawaii marketing. Unit prices were converted between product forms to compare the different tuna markets.

Fresh tuna market connections to, from, and within Hawaii were examined:

- Hawaii >>> Japan (Grade No. 1 bigeye and yellowfin tuna)
- Hawaii >>> U.S. West Coast (Grade No. 2 yellowfin tuna)
- Neighbor islands >>> Honolulu (Grade No. 1, 2 yellowfin tuna)
- Pacific basin >>> Honolulu (Grade No. 1, 2, 3 bigeye and yellowfin tuna)

Fresh marlin market connections are discussed qualitatively.

8.1 Hawaii - Japan Market Connection

Fresh tuna export from Hawaii to Japan is highly selective. Hawaii suppliers try to ship only grade No. 1 bigeye and yellowfin. Other source areas, which lack Hawaii's domestic marketing option, ship grade No. 2 tuna as well as No. 1.

Japan prices for Hawaii tuna exports were monitored during the June 30-July 14, 1994 market sampling conducted in Hawaii. Selling price ranged from 1,800 ¥/kg to 990 ¥/kg, considered above average because the survey period was characterized by large landings of coastal bluefin tuna in Japan and Japanese market conditions were only "fair" for imported bigeye and yellowfin tuna (K. Kono, Toho Corp., pers. comm.). On average, Hawaii tuna received the highest prices paid in Japan auctions for bigeye and yellowfin during 1994 market monitoring. Table 8-1 ranks all tuna producers by the average price received in Tokyo and southern Japan markets on days when Hawaii tuna were sold.

TABLE 8-1. Ranking of Source Areas by Average Tuna Price, 30 June - 12 July 1994

TOKYO: Fresh yellowfin tuna

Source	Pieces	Avg. Price on Days When Hawaii Tuna Sold (¥/kg)
Hawaii	29	1,455
Japan	26	1,320
Java	79	895

OSAKA/NAGOYA/SAPPORO: Fresh yellowfin tuna

Source	Pieces	Avg. Price on Days When Hawaii Tuna Sold (¥/kg)
Hawaii	50	1,508
Yap	73	1,366
Kosrae	82	1,020
Chuuk	100	943
Guam	663	825
Bali	166	810
Pohnpei	372	800
Taiwan	200	790
Fiji	5	730
Indonesia	39	575
Belau	74	534
Japan	37	412

(Table 6-1 - continued next page)

(Table 6-1 continued)

OSAKA/NAGOYA/SAPPORO: Fresh bigeye tuna

Source	Pieces	Avg. Price on Days When Hawaii Tuna Sold (¥/kg)
Hawaii	19	1,430
Florida	11	1,410
Philippines	11	470
Japan	3	200

Surprisingly, most of the fish exported during the study period were handline-caught yellowfin tuna. Individual shipments produced mixed results in Japan. Some shipments sold for remarkably high prices, considering market conditions. Apparently, premiums were paid for superior freshness, as well as for high fat content. Other shipments were less successful because some fish with defects (especially minor "burn") were discounted. As shown in Table 8-2, the average price received in Japan was somewhat higher than the average price for Grade No. 1 yellowfin at the Honolulu fish auction. Thus, the basic economic relationship was fulfilled:

If, $P_i - P_j \geq t_{ji}$ there can be trade from j to i

TABLE 8-2. Comparison of Japan and Honolulu Pricing For Grade No. 1 Yellowfin Tuna, 30 June - 14 July 1994

(1) Average Japan selling price during 1994 study period: ¥1,489/kg (h&g)

(2) Monetary exchange rate: ¥98 = US$1

(3) Japan marketing costs: 16% of selling price = ¥238/kg

(4) Net Japan revenue [(1) - (3)]: ¥1,251/kg

(5) Net return in USD [(4) / (2)]: $12.76/kg = $5.80/lb

(6) Packaging and air freight: $0.15/lb + $0.60/lb = $0.75/lb

(7) Net return to Hawaii [(5) - (6)]: $5.05/lb

(8) Net return to Hawaii on whole fish weight (7) x 90% g&g yield adjustment: $4.54/lb

(9) **Honolulu auction price: $4.25/lb**. Honolulu and Japan prices closely correspond.

Hawaii exports mostly longline-caught bigeye tuna to Japan and it was unusual for handline-yellowfin to be shipped. Yellowfin taken by handline during the summer of 1994 were of superior quality. Bigeye tuna caught during the summer season by the Hawaii longline fleet tends to have soft-textured muscle, which reduces its potential value for export unless there is visible fat to compensate. The few bigeye exported during the market survey were sold for prices that were break-even or slightly profitable for Hawaii shippers ($4.70/lb whole). Fish quality is superior and prices are higher in the winter season, when the majority of Hawaii bigeye tuna is exported.

No Hawaii-origin tuna was reported sold in the Japanese market during the second round of monitoring: June 22 - July 8, 1995. As in the 1994 survey, landings of coastal bluefin tuna in Japan dominated the Toyko market and conditions were considered "fair to weak" for imported bigeye and yellowfin tuna (K. Kono, Toho Corp., pers. comm.). Nevertheless, large quantities of fresh yellowfin tuna exported from the Indo-Pacific region were sold in regional markets outside Tokyo during this period. The breakeven price in Japan for fresh tuna exports from Indonesia, Micronesia, and Fiji is considered to be in the range of 700-800 ¥/kg. As shown in Table 8-3, few suppliers from the region made sales that were more than marginally profitable during the 1995 market survey. The survey represents only a two-week period but it is illustrative of the trend toward increasing supply and declining price for fresh yellowfin tuna in Japan.

TABLE 8-3. Average Japan Regional Market Prices For Fresh Yellowfin Tuna Imports: By Source Area, 22 June - 8 July 1995

REGIONAL MARKETS:	Fresh yellowfin tuna imports
Source	Avg. Market Price (¥/kg)
New Caledonia	972
Fiji	973
Chuuk	814
Pohnpei	774
Yap	730
Kosrae	713
	Breakeven price for most Indo-Pacific suppliers
Taiwan	688
Indonesia	687
Marshall Islands	635
Sri Lanka	622
Penang	612
Belau	578
Guam	559
Solomon Islands	480

8.2 Hawaii - U.S. West Coast Market Connection

Grade No. 2 yellowfin is the tuna product most commonly exported from Hawaii to the U.S. West Coast. Albacore tuna is gaining market share but many buyers are wary of bigeye tuna because of its softer-textured muscle. There is some demand for a higher grade of yellowfin tuna on the West Coast but buyers are not willing to pay the high prices that grade No. 1 tuna can command in Hawaii and Japan. Instead, the West Coast market recognizes a subdivision of the grade No. 2 known as No. 2+, which can be purchased at less cost than true grade No. 1 tuna.

Table 8-4 compares the delivered West Coast price for Gulf of Mexico and Hawaii grade No. 2 yellowfin tuna during the 1994 market survey. Except for troll-caught fish from Maui, Hawaii yellowfin tuna was not competitively priced on the West Coast. This finding was verified in interviews with Honolulu, Hilo and Maui exporters and with major San Francisco and San Diego buyers of No. 2 yellowfin. Maui-origin fish did compete successfully, whereas tuna from other islands did not. Local marketing opportunities on Maui are not as well developed as in Honolulu and on the island of Hawaii. Maui also lacks fish auctions and tuna marketing networks such as exist in Honolulu and Hilo, Hawaii. Hence, tuna fishermen have few options for marketing and ex-vessel prices tend to be lower than in Honolulu and Hilo.

TABLE 8-4. Comparison of Gulf of Mexico and Hawaii Grade No. 2 Yellowfin Tuna: Delivered U.S. West Coast Prices, 30 June - 14 July 1994

Source Area	Gulf of Mexico	Maui, HI	Hilo, HI	Honolulu, HI
Avg. price/lb at origin, > 80 lb whole YF	NA	$1.86	$2.50	$2.40
Avg. price/lb at origin, > 60 lb h&g YF (2)/0.80	$2.50	$2.26	$3.06	$2.92
Packaging and air freight cost/lb to Honolulu	NA	$0.25	$0.25	NA
Honolulu landed price, h&g (3)+(4)	NA	$2.51	$3.31	$2.92
Packaging and air freight cost/lb to U.S. west coast	$0.35	$0.40	$0.40	$0.40
Ave. price/lb, h&g landed U.S. west coast	$2.85 (3) + (6)	$2.91 (5) + (6)	$3.71 (5) + (6)	$3.32 (5) + (6)

Gulf-origin and Hawaii-origin grade No. 2 yellowfin tuna prices delivered to the West Coast were also compared during the 1995 market survey (Table 8-5). Because of major fluctuations in gulf tuna prices during the two-week survey, the analysis was done for three subperiods. Maui

landings of yellowfin were low, so only Honolulu-origin and Hilo-origin yellowfin were compared with gulf-origin fish. At no time was Honolulu tuna price competitive with gulf tuna on the West Coast. Hilo-origin yellowfin, on the other hand, was highly competitive during the first and third period of comparison and was equally priced with gulf tuna during the middle period.

Although the reputation of Hawaii grade No. 2 yellowfin tuna is generally good, many West Coast buyers purchase only longline-caught tuna because of the past reputation of handline-caught and troll-caught fish for poor shelf life. Fresh tuna distributors supplying the West Coast, central Atlantic Coast, Great Lakes, and resort areas in the southwest and Rocky Mountains generally require grade No. 2 tuna with relatively red muscle pigmentation. In other areas (Boston, portions of the southeast, mideast, midwest, and west), a paler grade (grade No. 2- / 3+) of tuna flesh can be marketed with less difficulty and even grade No. 3 tuna is regularly used for cooking. The opportunity to export these lower grades of fresh tuna was apparently overlooked despite an abundant supply in Hawaii. Obviously, a lack of mutual understanding about what constitutes an acceptable cooking-grade tuna in the less sophisticated U.S. markets inhibits the export of lower grades of fresh tuna from Hawaii and the Pacific.

TABLE 8-5. Comparison of Gulf of Mexico and Hawaii Grade No. 2 Yellowfin Tuna: Delivered U.S. West Coast Prices, 22 June - 8 July, 1995

Source Area	Gulf of Mexico			Hilo, HI			Honolulu, HI		
Date of Sale	6/22-6/27	6/28-7/5	7/6-7/8	6/22-6/27	6/28-7/5	7/6-7/8	6/22-6/27	6/28-7/5	7/6 7/8
Ave. price/lb at origin, > 80 lb whole YF		NA		$1.66	$1.28	$1.17	$2.54	$2.54	$3.26
Ave. price/lb at origin, >60 lb h&g YF (line 3) /0.80	$2.80	$1.92	$2.50	$2.07	$1.60	$1.46	$3.17	$3.17	$4.07
Packaging and air freight cost/lb to Honolulu		NA			$0.25			NA	
Ave. price/lb landed Honolulu, h&g YF (line 4 + line 5)		NA		$2.32	$1.85	$1.71		NA	
Packaging and air freight cost to US west coast		$0.35			$0.40			$0.40	
Ave. price/lb landed US west coast, h&g YF	$3.15 (line 4 + line 7)	$2.27	$2.85	$2.72 (line 6 + line 7)	$2.25	$2.11	$3.57 (line 6 + line 7)	$3.57	$4.47

8.3 Neighbor Islands-Honolulu Market Connection

The expansion of the tourist industry in Hawaii increased airline service between the islands and encouraged export of fresh tuna to Honolulu from the outer (Neighbor) islands, especially from Hilo and Kona, Hawaii, home ports for the state's small-boat tuna fleet. This fish is almost always caught by handline or troll methods, which have a past reputation for producing tuna of lower quality and with less shelf life than longline tuna.

Segments of the Hawaii island handline tuna fleet have worked hard to improve the quality of their catch. This became apparent during the summer 1994 market survey. Honolulu fish auction buyers were willing to pay premiums for handline-caught yellowfin tuna of superior quality but each fish (and fisherman) was carefully scrutinized because of the reputation of handline yellowfin to have poor shelf life, as well as "burnt" muscle. Troll-caught yellowfin marketed during the same period did not receive the same price premium, even if fish were grade No. 1 (see Table 7-3b). The explanation provided by Honolulu buyers was that troll-caught yellowfin that initially appear to be No. 1 often deterioriate rapidly (within two days) to a lower grade. Furthermore, troll-caught tuna is quarter-cut prior to sale at the Honolulu fish auction and marketing options are reduced for this product form.

Previously, handline-caught tuna shipped from the island of Hawaii to the Honolulu auction was also quarter-cut before sale. This simplified grading and eliminated later requests for credits due to unseen defects. Starting in summer 1994, handline-caught yellowfin shipped to the auction from fishermen of proven reputation was not quartered, allowing export to overseas markets.

Honolulu is a good marketing option for grade No. 1 yellowfin tuna landed on other islands, which lack the high-priced *sushi* restaurants that exist on the island of Oahu. To satisfy the quality requirements of this highly discriminating market niche requires a tuna product that will remain a grade No. 1 product for several days. Handline and troll yellowfin tuna that are initally graded as No. 1 have the unfortunate reputation of deteriorating after two days to grade No. 2.

The Hawaii tuna market analysis in Section 7.0 suggests that handline-caught and longline-caught grade No. 2 yellowfin are not differentiated by average price in the Honolulu fish auction. Recent success in exporting handline-caught yellowfin from Hawaii island to continental U.S. buyers further indicates wide acceptance of this product. As seen in Table 8-5, row (3), the average Hilo price of large handline-caught yellowfin was substantially lower than for the equivalent fish sold in Honolulu during the 1995 market survey. Further investigation indicated that the more quality-conscious handline fishermen were exporting their catch to Honolulu. The reason why more Hawaii island fishermen did not follow this example is apparently their uncertainty and mistrust of the Honolulu market. Based on past experience, both harvesters and buyers may expect disappointment and, therefore, they are reluctant trading partners.

8.4 Pacific Basin-Hawaii Market Connections

Fresh tuna is regularly imported to Hawaii from throughout the Pacific basin. Coinciding with the 1994 Hawaii market survey, information was collected from major Honolulu importers on the origin, species, quantities, grades and prices of fresh tuna imports. Table 8-6 compares average prices of imports with those for Hawaii domestic tuna.

The average price of imported grade No. 1 tuna is consistently much lower than the average price of domestic No. 1 tuna. Investigation revealed that imported tuna rarely satisfy the quality requirements for a true grade No. 1. Most tuna producing areas in the Pacific basin have the capability to ship grade No. 1 tuna to the Japan *sashimi* market. In most cases, the tuna that reaches Hawaii is grade No. 2+ at best.

TABLE 8-6. Comparison of Fresh Tuna Prices: Hawaii Imports from Pacific Basin and Domestic Landings, 30 June - 14 July, 1994

Source Area	Honolulu	Marshall Isl.	Fiji	Australia	Indonesia	Philippines
Lb of fresh YF imported, > 60 lb h&g, all grades	--	500	10,500	8,000	3,000	5,000
Ave. Price/lb, grade No. 1 YF, > 60 lb h&g	$5.36	NA	$4.50	$4.00-5.00	NA	NA
Ave. Price/ lb, grade No. 2 YF, > 60 lb h&g	$2.92	$3.45	$3.20	$3.40	$3.00	$3.15
Ave. Price/lb, grade No. 3 YF, > 60 lb h&g	$1.60	$2.80	$2.25	$2.50	$2.25	$2.25
Lb of fresh BE imported, > 60 lb h&g, all grades	--	800	NA	NA	NA	NA
Ave. Price/lb, grade No. 1 BE, > 60 lb h&g	$5.37	$4.50	NA	NA	NA	NA
Ave. Price/lb, grade No. 2 BE, > 60 lb h&g	$3.00	$3.75	NA	NA	NA	NA
Ave. Price/lb, grade No. 3 BE, > 60 lb h&g	$1.50	$3.00	NA	NA	NA	NA

Surprisingly, imported tuna graded as No. 2 and No. 3 were sold for higher average prices than similarly-graded domestic tuna. The interpretation of importers is that the Honolulu tuna market is usually undersupplied with top-grade tuna, so competitive bidding for grade No. 1 keeps the price high. The purchasing of grade No. 2 and No. 3 tuna is less competitive because Honolulu is usually well supplied. If a large supply of grade No. 2 and No. 3 tuna is landed by Hawaii's domestic fleet and is sold in a matter of hours at the Honolulu fish auction, industry sources believe that there is simply inadequate lead time to pre-sell the fish and to obtain the best possible price. Imported tuna, on the other hand, arrives in Hawaii on a regular schedule and importers usually have several days of advance notice to pre-sell the product. The extra time

allows them to obtain prices for grade No. 2 and especially grade No. 3 tuna imports that are sometimes higher than the Honolulu auction prices.

8.5 FRESH MARLIN MARKET CONNECTIONS

Fresh marlin is sold in the same markets as fresh tuna. The Japanese market pays premiums for marlin with high fat content. Striped marlin with marbled fat are caught off French Polynesia and the Cook Islands during the southern hemisphere winter. These fish receive prices in the range of 1,500- 3,500 ¥/kg. Hawaii marlin usually is not as highly valued and the average price in Japan is closer to 700-800 ¥/kg.

Fresh marlin is exported from South America to the U.S. at extremely low prices -- $2.50/lb for skinless blue marlin loin delivered to Miami. As a consequence, Hawaii marlin cannot usually compete in the continental U.S. market and export is frequently not an option. The price of marlin in Hawaii is, therefore, extremely sensitive to marlin supply. Large landings can flood the domestic market and depress prices. The usual range of price for blue and striped marlin is between $0.50/lb - $2.00/lb for whole fish.

9.0 FUTURE OUTLOOK FOR FRESH TUNA INDUSTRY AND IMPLICATIONS FOR PACIFIC ISLAND FISHERIES

Information obtained from international sources was used to assess the future outlook of the fresh tuna industry. Presentations and panel discussions at the INFOFISH Tuna '95 Conference in Manila, Philippines, were particularly productive sources. This important meeting congregates tuna industry leaders from around the world and focuses on the biological, environmental, socio-economical and trade issues facing the tuna industry. Additional information was obtained from telecom and personal interviews of tuna suppliers, buyers and graders in the U.S., South America, Europe, and Japan. Many of the interviews were conducted at trade shows, including Sea Fare '94 in Long Beach, California, 1995 International Boston Seafood Show, and 1995 Seattle Fishermen's Exposition.

9.1 Trends in Fresh Tuna Production

9.1.1 Asian Producers

The high cost of crews and vessel operations is causing tuna fishing by Japanese vessels to become uneconomical. Further attrition in the domestic fleet is expected (Taya, 1996). The Korean government is not particularly supportive of tuna fishing activities and fleet size will continue to decline. The remaining Korean fishing companies are making an effort to improve profitability by integrating vertically, especially in developing a domestic market for *sashimi* (Choi, 1996).

Taiwan, with longline fleets fishing throughout the Indo-Pacific, continues to be the leading supplier of tuna imported by Japan. A recent trend is for Taiwan to be the contractor of tuna longliners from the People's Republic of China, which will become a major fresh tuna supplier in the near future (Ho, 1996). The PRC longline fleet has the lowest operating costs in the Pacific basin but tuna production is at a much lower scale than other fleets.

9.1.2 Pacific Islands

The Pacific islands, with large exclusive maritime zones and tuna resources, continue to develop domestic fresh tuna fisheries, but on a relatively small scale. Hawaii and Fiji have been the most successful. Papua New Guinea, which controls some of the richest tuna fishing grounds in the Pacific, recently declared its intention to establish a domestic tuna industry.

9.1.3 Latin America

Fresh tuna enters the Japanese and U.S. markets from several producers in Central and South America. Ecuador is well established as an exporter of bigeye tuna. Venezuela and Costa Rica are rapidly developing as additional sources (San Miguel, 1996). Longline fishing is in the early stages in Nicaguara and Peru.

9.1.4 Indian Ocean

The tuna resources of the Indian Ocean are only beginning to be harvested for the fresh tuna market. The primary suppliers are Oman and Sri Lanka, with activity developing in the Seychelles and Mauritius.

9.2 Trends in Fresh Tuna Markets and Products

9.2.1 Consumption Patterns

Worldwide consumption of fresh and frozen tuna is increasing, although consumption of the traditional tuna products in the U.S. (canned tuna) and in Japan (*sashimi* tuna) is not. New markets are developing, especially in countries with growing economies and among consumer groups concerned about health and nutrition. Most notable are the creation and rapid expansion of Korea's *sashimi* tuna industry and of Europe's retail tuna industry. Domestic marketing of tuna is developing in Venezuela in conjunction with a national longline fleet and some predict that Australia may be ready to expand fresh tuna marketing. As tuna supply increases, marketing options will be crucial to maintain economic viability of the fresh tuna industry.

9.2.2 Quality Issues

During the 1980s, fresh tuna changed from a specialty seafood to a mainstream product in the U.S. Product knowledge and quality requirements were, by present standards, relatively low. Seafood marketers and consumers now recognize and value higher-quality tuna. In contrast, the U.S. market for canned tuna is declining and this trend has raised industry concerns about the quality of the canned product (Munoz, 1996).

The trend toward more sophisticated and discriminating purchasing is likely to be repeated in newly emerging markets, such as the more affluent nations in Asia, Europe and South America. Government regulations to improve seafood safety were recently implemented by the European Union countries and by the U.S. This should raise awareness of seafood quality.

Many of the longline fleets fishing in the Indo-Pacific are sacrificing tuna quality for high-volume production. Japan is the targeted market for virtually all fresh tuna landings outside of Hawaii and Fiji. Large supplies of medium to low-grade fresh tuna, especially yellowfin, threaten to saturate the Japanese *sashimi* market and force prices lower. As production increases, suppliers may divert lower-quality tuna away from Japan to other accessible markets, such as Hawaii and the U.S. mainland.

9.2.3 New Species in Fresh Market

Albacore tuna is gaining recognition in Japan and the U.S. as a substitute for yellowfin. The relatively low price of albacore in relationship to its quality provides marketers and consumers with excellent value. Albacore is known as the premium canned tuna species but in the *sashimi* and grilled tuna markets, it ranks behind other tuna species in buyers' preference. This situation may change with greater promotion and consumer education. Exclusive designation as the only "white meat" tuna for canning might be a selling point in other markets.

9.2.4 New Product Forms

The increasing supply of "reject" tuna produced by Indo-Pacific longline fleets has created opportunities to manufacture value-added products, such as fresh and frozen loins, tuna jerky, and reconstituted, "meat-like" foods. The raw material for value-added tuna products is from the low end of the quality and price range—grades No. 3 and No. 4. Quality requirements differ enough for the varied products that sub-divisions of these grades are now recognized. As new products and market niches develop, the trend is toward greater differentiation in the tuna quality spectrum, as shown in Figure 9-1.

9.2.4.1 Fresh tuna loins

Processing of fresh tuna loins has several advantages but this highly perishable product must be transported to market and sold within 48 hours:

- Value added by local economies at tuna landing sites;
- Savings on air freight compared to shipping less-processed tuna; and
- Greater certainty in grading quality after tuna muscle is exposed by loining.

9.2.4.2 Frozen tuna loins

Despite an existing preference for fresh tuna in the U.S., a high-quality frozen loin product with good shelf life could gain a significant market share if reasonably priced. Consequently, several importers are exploring the use of low-grade yellowfin tuna for processing of quick-frozen loins. If buyers recognize the higher value of such a product compared to conventionally frozen tuna loins, then the price may move closer to that of fresh cooking-grade tuna.

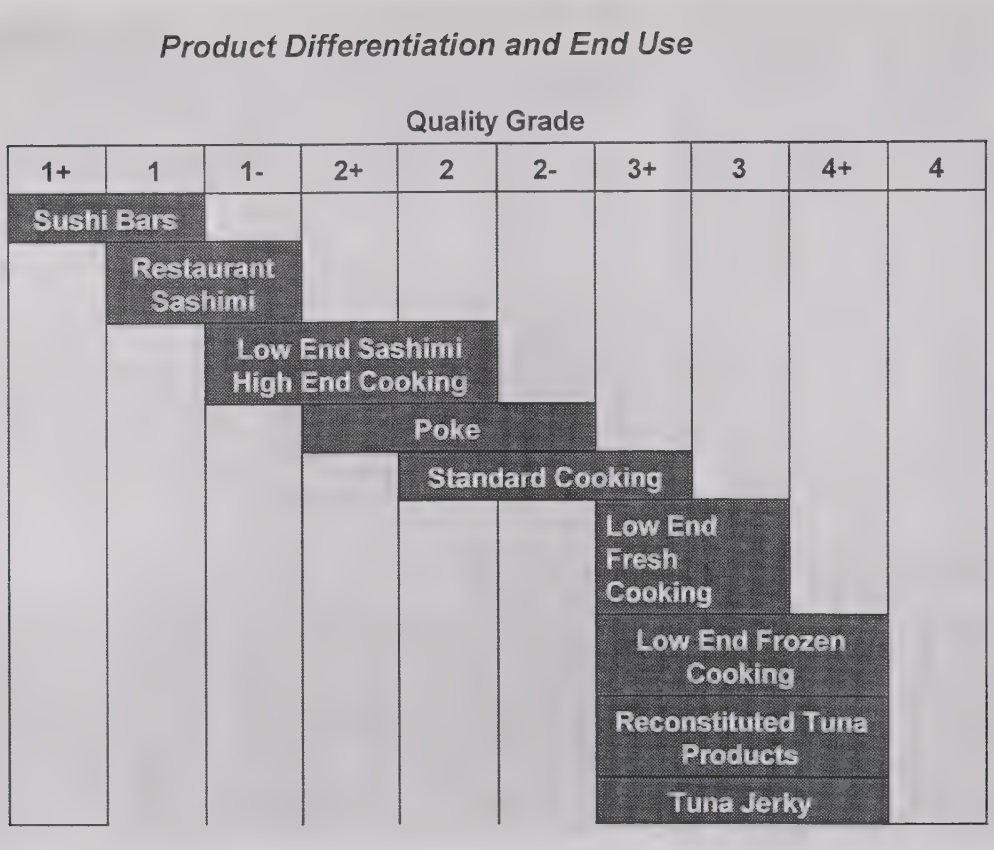

Figure 9-1. Trends toward increased differentiation in the fresh tuna market.

9.2.4.3 "Meat-like" products

Reconstituted products, such as tuna burgers, hams or sausages may have potential but the markets for such products have not yet been fully tested or evaluated. Processors of such products try to promote tuna's resemblance to meat.

9.2.4.4 Tuna jerky

Tuna jerky is processed in Hawaii and other Pacific islands, as well as in continental U.S. Low-grade tuna is marinated and dried to produce a product which is similar to beef jerky. The market in Japan is reported to be significant but this product alone is unlikely to absorb the supply of low- grade fresh tuna which will become available. The advantage of jerky is that processors with poor air transportation links to fresh tuna markets can produce a shelf-stable product that does not require refrigeration while in transit overseas.

9.3 The Potential for Oversupply

International expansion of tuna fisheries will continue and there is potential for oversupply, particularly of Grade No. 2 tuna.

- The Japanese market for *sashimi* tuna appears to have reached a maximum level of consumption.
- Japanese tuna fleet reduction will continue because of the increased cost of fishing.
- Japanese reliance on fresh tuna imports will increase and oversupply is a strong possibility.
- Oversupply will create downward pressure on Japanese tuna prices, especially for lower-quality tuna.
- Suppliers will seek alternatives to Japan for marketing lower-quality tuna.
- Downward pressure will be felt most in No. 2 grade, with a shift in target market for this grade from Japan to the U.S.
- U.S. domestic production of fresh tuna will increase if the Atlantic longline fishery is closed by late-year swordfish quotas and fishermen shift to tuna.
- U.S. imports of fresh tuna, especially from Latin America, will continue to displace domestic tuna from East Coast markets.
- Larger supplies of domestic and imported product may drive down No. 2 tuna prices in the U.S. market.

9.4 Possible Strategies for Pacific Island Tuna Suppliers

To compensate for a possible decline in No. 2 grade tuna prices, Pacific island suppliers would be prudent to consider the following strategies:

- Target bigeye tuna because of its price stability in Japan.
- Increase the proportion of No. 1 grade tuna through improved handling.
- Investigate alternative markets for premium tuna products in countries with rapidly-growing economies.
- Establish greater price stability for low-quality tuna and by-catch by diversifying products and market niches and through vertical integration of tuna producers and processors.

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